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streams of particles, practically parallel, and of relatively small diameter impinging on the Earth is negatived. Such a stream of particles could not be effective at positions so remote from each other as the E. and W. limbs of the Sun.

Stonyhurst College Observatory,
January 1905.

Observations of the Spectra of Sun-spots, Regions C to D.
By A. Fowler.

Introductory.

The observations of the spectra of sun-spots forming the subject of the present paper were made somewhat irregularly during the period 1903 October 15 to 1904 December 31 Detailed observations of widened lines were made on twenty-three separate days, and fifty-three observations of the appearance of the C line in and near spots were made on thirty-five days. The observations were restricted almost exclusively to the red end of the spectrum between C and D_2, and as many as possible of the affected lines in this region were recorded. They are therefore comparable with the observations made by Father Cortie at Stonyhurst,* and the results are of some interest as showing the degree of agreement between two independent observers working on essentially the same plan. It is possible also that some points in the discussion of the observations which I have attempted may be suggestive to other observers.

Mode of Observation.

All the observations were made with an "Evershed" two-prism solar spectroscope by Hilger, attached to the 6-inch Troughton equatorial provided for the instruction of students at the Royal College of Science, South Kensington. The definition of the spectroscope is remarkably good, and the dispersion is adequate for the identification of most of the lines. There are of course many close doubles which cannot be clearly resolved with this equipment; but if such were widened the affected component could often be judged by noting on which side the widening seemed to lie; in other cases it remains doubtful which of the components was affected.

The approximate positions of the lines were read off from Rowland's map in the usual manner, and were afterwards corrected to two places of decimals by reference to the tables of solar lines.

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* *Mem. R.A.S.* vol. l. pp. 30–56; *Monthly Notices*, vol. lxiii. pp. 468–480. Summarised in *Astrophys. Jour.* vol xx. pp. 253–265.

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Some difficulty was found at first with regard to a suitable scale by which to indicate the amounts of widening of the lines. Father Cortie's method is to state the extent of widening in tenths of the normal width of the corresponding solar line, but I found it extremely difficult to assign numbers on this plan to lines which are very feeble in the Fraunhofer spectrum; there is, moreover, the objection that the unit of widening is different for different lines. I therefore decided provisionally on a simple scale ranging from 5 for the lines most obviously widened and darkened to 1 for those in which the widening could only just be recognised with certainty, hoping that the discussion of the results would eventually suggest some better system. The numbers assigned include the combined effects of widening and darkening and directly indicate little more than the relative ease of detection. Towards the end of the series of observations, as explained later on, it was concluded that the most useful method of recording the lines is to note the actual intensities of the spot lines, by comparison with neighbouring solar lines outside the spot spectrum.

It only rarely happened that the whole of the region C to D could be minutely examined in a single observation, so that usually only the principal lines throughout this part of the spectrum were noted, or a smaller region explored more completely. By varying the latter from time to time, a fairly representative table of spot lines for the period covered by the observations has been secured, but the record may be far from perfect as regards the less affected lines. The region C to D, comprising 1700 lines in Rowland's tables, is in fact much too extensive for a single observer to explore fully; but if the observations had been restricted to a much smaller region, any attempted generalisations would have been less satisfactory.

Description of Table.

The lines most affected appear to have been identical in all the spots examined; and, in accordance with the results of other observers, many of these were found to be due to vanadium and titanium. The daily records differ somewhat as regards the less affected lines; but, taking account of the difficulties of observation and the differences of observing conditions, it is possible that these apparent variations from spot to spot were chiefly due to the imperfections and incompleteness of the records. Moreover, the period of observation was too short to be likely to exhibit any marked changes depending upon the sun-spot period, such as that discovered by Sir Norman Lockyer and confirmed, in part, by Father Cortie. It therefore seems unnecessary to give all the details of the individual observations, and the results are accordingly summarised in the accompanying table.

It is scarcely necessary to point out that the widened lines do not constitute the whole of the spot spectrum; all the Fraun-

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hofer lines are usually present, and there are, in addition, "spot bands," some of which were also observed. There is also the "continuous" absorption, but the dispersion employed was insufficient to show the breaking up of this into closely adjacent fine lines which has been noted by Young and Dunér.

The first column of the table gives the wave-lengths of the affected lines, as taken from Rowland's tables.

The origins of the lines are indicated in the second column, these, with few exceptions, being as assigned by Rowland. Photographs of the spectra of vanadium and titanium which I have taken on plates stained with pinachrome show a few additional lines of these elements; but as the wave-lengths need confirmation with higher dispersion, possible origins depending upon them are noted in the column of Remarks. Apparent coincidences with telluric lines are not included as origins, but are also indicated in the column of Remarks.

Column 3 shows the number of times each line was observed. The greatest number is eighteen; but, considering the nature of the records, it is not to be supposed that the lines noted on fewer occasions were necessarily not affected when not recorded.

Column 4 indicates the mean "widening" on the arbitrary scale which has already been mentioned. The numbers derived directly from the observations have been multiplied by 2, in order to reduce them to the more convenient scale which gives 10 for the maximum.

Column 5 gives the ordinary intensities of the lines in the Fraunhofer spectrum according to the estimates of Rowland. A line of intensity 1 is clearly visible on the map; and below this the lines, in order of faintness, proceed from 0 to 0000, indicating lines more and more difficult to see.

Besides the references to coincidences with telluric lines and probable coincidences with previously unrecorded lines of vanadium and titanium, column 6 contains a few general remarks, and also indicates by a † the lines which do not appear in Father Cortie's summary of the Stonyhurst observations. Closely adjacent lines, observed by Cortie in some cases, are indicated by a wave-length following the †.

Table I.

Widened Lines between D and C.

Wave-lengths.	Probable Origins.	Number of Observations.	Relative Mean Widening.	Intensity in Sun.	Remarks.
5890·19	Na	10	7	30	D_2
95·16	...	4	3	0	A wv *
96·16	Na	10	7	20	D_1
98·38	...	2	4	4	A wv *
99·52	Ti	8	6	1	

* Indicates that the line is not in Cortie's table.

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Wave-lengths.	Probable Origins.	Number of Observations.	Relative Mean Widening.	Intensity in Sun.	Remarks.
5900·14	...	1	5	2	A wv
00·26	...			4	A wv
03·75	...	8	5	1	A wv *
11·37	...	1	7	0000	*
13·21	...	1	4	3	A wv *
15·65	...	4	4	1	A wv
16·48	Fe	8	5	3	*
18·77	Ti	12	7	0	* (18·64 A wv)
22·33	Ti	10	5	0	* (22·74 A wv)
23·87	...	1	6	1	A wv *
32·31	...	1	4	5	A wv
38·27	...	16	7	0	A wv. Possibly Ti
41·99	Ti	8	8	00	* (41·85 A wv)
44·95	...	7	6	1	A wv
49·57	Fe	3	6	1	
53·39	Ti	5	7	1	
55·17	...	3	3	1	A wv *
56·92	Fe	3	7	4	
60·20	...	2	3	0	A ? *
66·06	Ti	15	7	2	
71·56	...	4	5	1	
78·77	Ti	15	8	1	
85·44	...	1	6	0	A wv *
88·79	...	4	3	0	A wv *
92·22	...	5	5	00	A wv *
99·92	Ti	16	6	0	"Always much widened" (Cortie)
6005·77	Fe	11	5	1	
08·19	Fe	1	4	4	
12·45	Ni	7	5	1	
13·72	Mn	1	4	6	
16·86	Mn	2	4	6	
18·52	...	1	4	0	
22·02	Mn	1	4	6	
39·95	V	16	9	0	"Always much widened" (Cortie)
46·25	...	2	4	0	*
53·91	Ni	4	6	0	

* Indicates that the line is not in Cortie's table.

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Wave-lengths.	Probable Origins.	Number of Observations.	Relative Mean Widening.	Intensity in Sun.	Remarks.
6054·29	...	2	5	00	A ? *
57·48	...	1	4	00	
58·39	...	5	6	000	* Possibly V
63·08	...	15	6	0	"Much widened always (Cortie)
64·85	Ti	17	7	00	
81·67	V	18	7	0	
82·93	Fe	1	4	1	
84·33	...	1	4	0	*
85·47	Ti, Fe	18	6	2	
86·50	Ni	1	4	1	
88·05	...	2	4	00	
90·43	V	15	6	2	See Note (1)
91·40	Ti	2	4	0	
93·86	Fe	1	2	2	
98·47	...	2	3	0	
6100·49	...	1	4	00	
02·39	Fe	7	6	2	This group appears to be usually strengthened in spots. The Ca line is probably the most widened
02·94	Ca			9	
03·40	Fe			4	
11·87	V	16	8	0	* (11·29 Ni)
19·74	V	17	8	1	
19·97	Ni	1	4	0	
22·43	Ca	5	5	10	
26·44	Ti	16	7	1	
29·19	Ni	1	4	1	
35·58	V	15	7	00	Spot line possibly includes Cr 6135·99
45·23	...	1	4	2	
50·36	V	15	7	0	
54·44	Na	15	6	2	
56·24	...	1	4	00	
60·96	Na	3	6	3	
61·50	Ca			4	
66·65	Ca	3	2	5	
69·25	Ca	1	4	6	
69·78	Ca	2	5	7	
88·21	Fe	1	4	4	

* Indicates that the line is not in Cortie's table.

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Wave-lengths.	Probable Origins.	Number of Observations.	Relative Mean Widening.	Intensity in Sun.	Remarks.
6189·20	Co	1	4	00	A wv? *
99·40	V	17	9	0	
6210·90	...	17	7	00	Possibly Scandium. See Note (2)
12·28	...	2	2	00	
14·08	V	2	5	000	*
15·36	Fe	1	6	5	
15·63	Ti			000	*
16·57	V	14	6	1	Attributed to V by Young and seen in new photographs of V
21·01	Fe	5	5	0	Possibly Ti
21·55	Fe	3	5	00	
24·72	V	11	5	000	
29·44	Fe	4	5	1	
30·94	V, Fe	1	4	8	Strong compound line
32·86	Fe	1	4	3	
33·08	...	1	4	0000	* Possibly V
40·17	...	4	5	00	
43·06	...	18	10	000	"Most widened of all the lines" (Cortie). See Note (3)
43·32	V			1	
49·86	...	2	4	000	*
52·05	V	12	5	00	
56·57	Ni, Fe	1	6	6	
58·32	Ti	8	6	2	
58·57	V			0000	
58·93	Ti	4	5	3	
59·80	...	1	2	00	
61·32	Ti	12	5	1	
61·50	V			0000	
66·55	V	5	4	000	Attributed to V by Mitchell and seen in new photographs of V
69·08	V	13	6	000	
71·49	Fe	2	2	0	
74·87	...	16	7	00	A wv. Possibly V
79·08	...	3	5	2	A (O)
80·83	Fe	3	5	3	
85·38	V	9	6	00	? *
86·36	...	2	4	0	

* Indicates that the line is not in Cortie's table.

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Wave-lengths.	Probable Origins.	Number of Observa-tions.	Relative Mean Widen-ing.	Intensity in Sun.	Remarks.
6287·95	...	1	4	1	A (O)
89·61	...	1	5	1	A (O) *
93·03	V	11	7	000	? * (92·38 ?)
96·58	V	12	7	0000	? * (96·17 A [O] ?)
6301·72	Fe	1	6	7	
04·55	...	1	3	000	*
06·02	...	16	9	2	A (O) "Generally much widened" (Cortie). Possibly due to Scandium. See Note (2)
18·24	Fe	1	5	6	
27·82	Ni	1	2	2	
30·32	Cr	13	6	1	This is the strongest red line of Cr
62·56	Zn	1	6	1	Said to be variable in Sun
63·09	Cr, Fe	7	6	2	
64·92	...	1	2	0	
66·56	Ti	6	6	000	
66·71	Ni			0	
81·6	...	5	...	...	"Spot band"
89·0	...	5	...	...	"Spot band"
92·75	...	3	3	0	
6400·22	Fe	1	4	8	
05·98	...	3	4	00	
13·80	...	4	5	0000	? *
25·08	...	1	6	00	
35·26	...	2	4	0000	*
39·29	Ca	8	6	8	
50·03	Ca	8	6	6	
52·54	...	3	5	00	
55·23	Co	5	5	0	
55·82	Ca	8	7	2	
62·78	Ca	9	6	5	
62·97	Fe			3	
63·97	...	1	4	0000	A ? * (63·72 ?)
64·90	...	6	5	00	
71·89	Ca	12	6	5	
91·88	Mn	1	4	000	

* Indicates that the line is not in Cortie's table.

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Wave-lengths.	Probable Origins.	Number of Observations.	Relative Mean Widening.	Intensity in Sun.	Remarks.
6494·00	Ca	4	6	6	
95·21	Fe	2	6	8	
99·88	Ca	2	5	4	
6504·42	...	2	5	0	A wv *
09·08	...	6	6	00	A wv * (08·83?)
44·14	...	2	4	2	A wv
46·48	Ti, Fe	1	6	6	
54·47	Ti	4	6	0	*
56·31	Ti	1	6	1	*
63·05	H	53	...	40	See Note (4)

Notes on some of the Lines.

(1) 6090·43. In his preliminary table Rowland assigned this line to Fe, while in the "corrections" it was amended to Ti; V. My photographs show a strong line of V apparently coincident with 6090·43, while titanium shows a line of moderate intensity which appears to agree with 6091·40. Mitchell (*Astrophys. Journ.* vol. xix. p. 358) assigns the former to Fe, V ?, and the latter to Ti ?.

(2) 6210·90 and 6306·02. These lines were always widened, and are very probably due to scandium. According to Thalén, the two strongest lines of scandium in the red are 6210·0 (intensity 8) and 6304·0 (intensity 10), which would become 6211·0 and 6305·1 when corrected to Rowland's scale. The differences between these and the spot lines are not greater than others which may be found in Thalén's observations as compared with Rowland's. The identification is the more probable, as scandium lines have been noted among the most widened lines in the region more refrangible than D, notably, 5672·05. It is, however, important that the wave-lengths of the red lines of scandium should be redetermined.

(3) 6243·06 and 6243·32. Both lines are weak in the Sun (000 and 1 respectively), and the widening is so great that I have not been able to determine whether both lines are affected or only one of them. Rowland attributes the weaker line to vanadium, while Mitchell assigns both to that element. My photographs show a very strong line in this position, which would correspond better in intensity with the solar line 6243·3 than 6243·0; but, possibly through lack of dispersion, they do not show two lines. It seems reasonable to suppose, however, that the solar line 6243·3 should be attributed to vanadium, and that this is the line most affected in spots.

(4) 6563·05. Special attention was given to the appearance presented by the C line of hydrogen in and near all spots on the disc on twenty-five different days. Treating observations of the same spot made on different days, or of different spots made on the same day, as separate observations, the line was not notably affected in 31 observations; it was displaced or "knotted," but not reversed, on five occasions; reversed and knotted or displaced in 12 observations; and simply reversed in 5 observations. The displacement of the dark line was sometimes towards the red and sometimes towards the violet.

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* Indicates that the line is not in Cortie's table.

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Comparison with Stonyhurst Observations.

Of the 146 lines contained in the foregoing table of spot lines 109 appear also in Cortie's list, 9 others are probably common to the two, and 28 were not observed by Cortie. Several of the lines not seen by Cortie, or for which slightly different wave-lengths are given, are due to vanadium and titanium, and in view of the presence of so many other lines due to these elements they might be expected to appear in the spots.

Nearly 200 lines recorded by Cortie do not appear in my table, but the great majority of these were only noted as slightly widened. Only 14 of them had a mean widening of 10 or more on Cortie's scale, and even these were seldom observed; 7 of them in fact were only recorded once, 3 of them twice, 1 three times, 1 four times, and 2 six times.

It is probable that the greater number of lines in Cortie's table is to be chiefly accounted for by the fact that his observations include all phases of the sun-spot cycle, whereas mine only cover a short period preceding a maximum. Many of the additional lines are due to iron and nickel, and Cortie states that his observations "confirm the fact that the iron lines, while not displacing other faint lines, are more affected in minimum than in maximum spots."

There is a difference of another kind between the two sets of observations: namely, that in spite of the much smaller total number of my observations, some of the lines were more frequently recorded than at Stonyhurst. The majority of such lines are due to vanadium, 6090·4, for example, being only once recorded by Cortie, as against 15 times by myself. The chromium line 6330·3 is another notable example, having been only twice recorded by Cortie, while I have never missed it when this part of the spectrum was examined in sufficient detail.

These differences, as well as some of those previously mentioned, might conceivably be explained by supposing that the lines of vanadium, titanium, and chromium were generally more strongly developed during the period covered by my observations than in the Stonyhurst period. It is more probable, however, that they are to be accounted for by the difficulty of making complete records of the affected lines when a large region of the spectrum is undertaken.

The agreement between the two series of observations, so far as they are comparable, may be considered very satisfactory on the whole.

Interpretation of Widened Lines.

In attempting to interpret the sun-spot spectrum there is no obvious reason why we should depart in the first instance from the ordinary methods of spectrum analysis. Many of the

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characteristic lines are undoubtedly due to familiar elements, and, given perfect observations, it should not be difficult to determine the conditions under which the corresponding vapours exist in spots unless altogether outside our laboratory experience. If, for instance, the vapours are at a temperature not greatly different from that of the vapours which produce the Fraunhofer lines, it might be expected that the relative intensities of the lines of a given element in spots would be the same as those of the corresponding lines in the arc spectrum of the element; while if the temperature were very different, the intensities of certain lines would be changed in accordance with experimental results.

From this point of view it would appear that what is needed in the observations is not so much a record of the amount of widening of the various lines as of their actual intensities in the spot spectra. The widening of a line may, in fact, generally be regarded as an intensification such as would be produced by an increase in the thickness and density of the absorbing vapour.

The most convenient scale for representing the intensities of the spot lines is furnished by Rowland's estimates of the Fraunhofer lines, and I have accordingly aimed at reducing my observations so as to indicate the intensities of the widened lines on the solar scale. For this purpose several observations of lines of different intensities were made in which the spot line under observation was compared with neighbouring Fraunhofer lines outside the spot spectrum and the equivalent solar intensity directly obtained. The line 6243·3, for example, reaches an intensity in the spots about equal to that of the iron line 6230·9 in the Fraunhofer spectrum, which is given as intensity 8 in Rowland's table; the intensity of the spot line may therefore be conveniently considered to be 8. In order to utilise the previous observations the widenings of the lines were also noted on the original arbitrary scale, and from the data thus obtained an interpolation table was made so that the equivalent solar intensities of all the lines which had been previously recorded could be approximately derived. In the absence of evidence to the contrary, lines not noted as widened must be assumed to have at least their normal solar intensities in the spots.

A discussion of the observations on this basis strongly suggests that the vapours producing the special selective absorption in spots do not differ very greatly in temperature from those which produce the Fraunhofer lines: that is, within the limits of error of estimation, the relative intensities of the lines of vanadium, &c., in spots are the same as those of the corresponding lines in the Fraunhofer or arc spectrum. The absolute intensities of the lines are, of course, greater in the spot spectrum; but to account for this it is unnecessary to go beyond the simple supposition that certain vapours are present in spots in greater quantity, and with greater density, as compared with the general absorbing atmosphere of the Sun.

This interpretation of the spot spectrum receives its greatest

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support from the discussion of the spot elements which are only represented in the Sun by comparatively faint lines—namely, vanadium, titanium, and chromium. The nature of the evidence will be sufficiently gathered from the part of the titanium spectrum illustrated in fig. 1. The upper spectrum indicates the relative intensities of the Ti lines in the Sun according to Rowland; the middle spectrum shows my own estimates of the intensities of the lines in the arc spectrum, and the lower one indicates the equivalent solar intensities of the lines in spots, determined partly by direct observation and partly by interpolation as already explained. (The line 6085·47 in the Sun is compounded of iron and titanium, and the solar intensity due to the latter is indeterminate.)

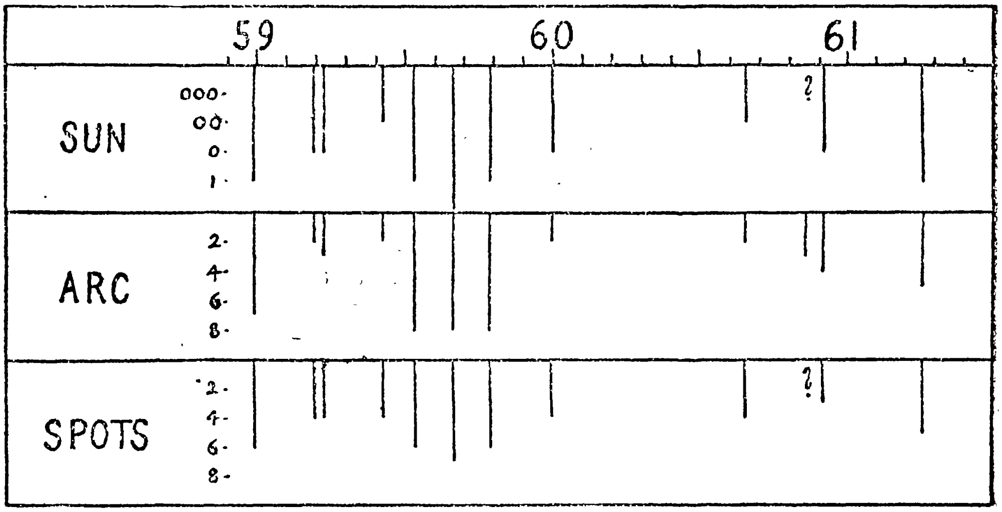

Fig. 1.—The relative intensities of titanium lines in spots compared with the intensities in arc and Sun.

It will be seen that the relative intensities of the lines in spots are in fair agreement with those in the Sun and arc, and the comparison therefore suggests that all the lines of titanium in spots are strengthened in proportion to their intensities in the Sun. Cortie has, in fact, already noticed that the most widened lines of titanium are among the brighter lines due to this element.*

Similar results are obtained for vanadium; and in the case of chromium, which only shows three faint lines in this part of the spectrum, the strongest line in the spots is also the strongest in the arc spectrum. The observations of individual spots lead to the same conclusion, assuming that the occasional omission of lines may be attributed to the difficulty of making complete records.

In the case of spot elements which yield Fraunhofer lines of

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* *Mem. R.A.S.* vol. l. p. 46.

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widely different intensities, the weaker lines tend to appear relatively "more widened" than the stronger ones, but it by no means follows that this implies an inversion in the intensities of the lines. It is easy to show that, in photographs at least, a general strengthening of all the lines belonging to an element produces a more obvious effect on the weaker lines than on the strong ones, though all may be intensified in the same ratio. It is therefore probable that the widening of strong solar lines will generally be under-estimated in comparison with that of the weaker ones, or even passed without record. In my own observations, for example, I have never included the strong calcium line 6162·39 (intensity 15 in Sun) among the affected lines, though many other lines due to the same element were noted; nevertheless the fact that it has been very frequently recorded by Cortie suggests that it was really widened at the time of my observations but was overlooked.

However, if intensities and not "widenings" be considered, the results for calcium and sodium are in accordance with those deduced from the behaviour of the lines of vanadium, titanium, and chromium. The strongest lines in the spots are also the strongest in the Sun and arc.

The observations of the lines attributed to iron, nickel, cobalt, and manganese are inadequate for useful discussion, but it is probable that lines of these substances were not much affected during the period of observation.

Telluric Lines.

Several of the widened lines apparently coincide with some of the telluric lines of the Fraunhofer spectrum, a few of them being due to oxygen and a greater number to water vapour.

With regard to the coincidences with lines of water vapour Father Cortie points out that the widening may be really due to faint solar lines in their immediate vicinity, or that the appearance of widening may be fictitious. That the latter is sometimes the case is suggested by the fact that many of the lines in my own table are absent from Cortie's, and *vice versa*. The first suggestion doubtless also applies to some of the lines, for of the lines common to the two series the two most prominent ones at 5938·27 and 6274·87 are probably due to titanium and vanadium respectively.

As to the oxygen lines, Father Cortie considers that "the widening of some oxygen lines in sun-spots, particularly in the *a* band (beginning at 6278·30), seems to be a real phenomenon," but much additional evidence is necessary to establish this view. Only four such lines appear in my table, and the one by far the most frequently observed, both by Cortie and myself (6306·02), is in all probability due to scandium (see note 2 to table). It must be remembered also that the lines of oxygen are structurally

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related,* and it is, therefore, very improbable that only isolated components would be widened if cool oxygen were really present.

Further investigation of metallic spectra in the red end will doubtless throw additional light on this question.

The Spot Bands.

Four positions are mentioned by Cortie as marked by the occurrence of "spot bands," namely—

6150·36	Band at this position once.
6306·02	A band near here.
6380·96	Spot-band position.
6388·63	" "

In the case of the first two I have not recorded anything different in appearance from the ordinary widened lines, the first being due to vanadium and the second probably to scandium.

I have, however, recorded the remaining two as bands on five occasions, and my most satisfactory estimates of their wave-length are 6381·6 and 6389·0. They seemed to present the appearance of ill-developed flutings, degrading towards the violet, or of narrow bands sharper on the red side, but not extending more than one or two tenth metres. A somewhat different description is given by Mitchell,† who observed on 1904 April 15 that the region 6380 to 6400 was resolved into seventeen groups of fine lines similar in appearance to G under low dispersion.

In four of the spots showing these bands it was noted that the C line was neither reversed nor distorted, while in the fifth (1904 October 29) C was brilliantly reversed just outside the spot, but not in the umbra, where the bands were observed. All the spots in which the bands were seen were comparatively large and the widened lines strongly marked.

An inquiry into the probable origin of the bands has so far been fruitless. They seem to have nothing in common with the titanium flutings which are so characteristic of the Antarian, or third type, stars. Neither are any bands in corresponding positions found on my photographs of the banded spectra of vanadium, chromium, manganese, or iron.

Besides the bands in the red, I have also several times observed those in the region more refrangible than *b*, some of which were first recorded by Maunder, and have recently been photographed by Hale.‡ So far as they go, my estimates of the positions of the bands are in good agreement with those of Hale, as will be seen from the following comparison :—

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* Lester, *Astrophys. Journ.* vol. xx. p. 81, among others.

† *Astrophys. Journ.* vol. xix. p. 359.

‡ *Ibid.* vol. xvi. p. 220.

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Hale.	Fowler.	Remarks.
5163·72 *nb*	...	...
5163·06 *d*	5163·0 *d*	Maunder 5163·3
5160·15 *d*	5160·2 5159·8	„ 5160
5157·86 *n*	...	...
5156·80 *t*	5157·2 5156·8	Maunder 5157·2
5150·03 *d*	5150·4 5149·9	...
5147·72 *d?*	5147·65 *n*	Ti line
...	5145·64 *n*	„ „
5144·03 *d*	5143·9 5143·5	...

n = narrow, *b* = band, *d* = double, *t* = triple.

No origin for these bands has been traced, but their occurrence in pairs rather suggests a common origin.

In view of the possible relation of the sun-spot bands to the banded spectra of the fourth-type stars, careful observations were made in the position of the head of the carbon fluting 5165·42, but no evidence of the presence of this fluting in spots was obtained.

All the spot bands thus remain unidentified, and they appear to have no connection with the bands which are characteristic of stars of the third and fourth types.

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Note on the Determination of the Longitude Paris-Greenwich in the Year 1902.

(*Communicated by the Astronomer-Royal.*)

In view of the discordance between previous determinations of the longitude of Paris-Greenwich, the International Geodetic Conference in 1898 expressed the view that a redetermination was desirable. It was arranged by M. Lœwy and the Astronomer-Royal that the redetermination should be undertaken in concert by the two observatories of Paris and Greenwich. Owing to the determination of the longitude Greenwich-Killorglin in 1898 and the eclipse expeditions of 1900 and 1901 it was not found practicable to commence this work till 1902.

The programme arranged in conjunction with M. Lœwy provided for the determination being made in two stages—in the spring and autumn of 1902. The instruments used were the four portable reversible transits belonging to the Royal Observatory which had been used in previous longitude determinations from 1888 to 1898. Each observer kept the same instrument throughout, taking it with him from Paris to Greenwich, or Greenwich to Paris. The instruments were distributed thus :—

Observer...	M. Bigourdan	M. Lancelin	Mr. Dyson	Mr. Hollis
Transit instrument	E	D	B	C

The observing stations at Greenwich were the Transit Pavilion and an adjacent wooden observing hut in the front court; the observing stations at Paris were in the grounds to the south of the Observatory and a little to the east of Cassini's meridian.

The French observers originally selected by M. Lœwy were M. Renan and M. Bigourdan, but owing to the illness of M. Renan he was replaced by M. Lancelin. The English observers were Mr. Dyson and Mr. Hollis.

Independent determinations of longitude were thus made simultaneously by the French and English observers, using adjacent stations and similar instruments. A double interchange of observers and instruments was made both in the spring and autumn. In the autumn the stands were also changed with the instruments. The programme of observations required clock-errors to be determined simultaneously at Greenwich and Paris on three, six, and three full nights respectively in the three parts of each determination. The following table gives details of the number of nights of observation of the English observers :—